

ASTR 2030 Black Holes Fall 2003. In class group Project 2. Th Sep 18.

Scribe's name:

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River Model of Black Holes

According to the River Model of Black Holes, the behavior of objects near black holes is precisely as if space were falling like a river into the black hole. For spherical black holes, this model was discovered by the French mathematician Painlevé in 1921, although Painlevé failed to understand the physical import of his discovery. In the model, space falls inward at the Newtonian escape velocity $v = \sqrt{GM/r}$. The infall velocity is less than the speed of light c outside the horizon, equals the speed of light c at the horizon, and exceeds the speed of light c inside the horizon.

What does the river model predict for the answers to the following questions:

1. Suppose that you are a light beam (therefore moving at the speed of light) exactly at the horizon. What would happen to you if were pointed directly outward? [Do you fall in? Do you move out? Do you move sideways?] What would happen to you if you were pointed mostly but not exactly outward?
2. In what way, if any, does this behavior differ from what Newtonian gravity would predict? [In Newtonian gravity, a light ray emitted from a mass whose escape velocity equals the speed of light c would fly outward on a parabolic curve for ever, slowly decelerating to a halt, but never quite stopping, in principle reaching to infinite distance after infinite time.]
3. Suppose that you are a light beam orbiting the black hole in a circular orbit. On this orbit, the so-called "photon sphere", are you at the horizon, inside the horizon, or outside the horizon?
4. Make a connection between the appearance of the sky if you hover just above the horizon of a black hole, and special relativistic beaming.